FIELD OF THE INVENTION

The present invention relates to an electrolytic capacitor, especially, an electrolytic capacitor having a low impedance characteristic and a high withstand voltage characteristic.

BACKGROUND OF THE INVENTION

An electrolytic capacitor typically has a structure such as shown in Figs. 1-2. That is, an electrolytic capacitor typically includes an anode electrode foil 2 made of a band-shaped high purity aluminum foil where the effective aluminum foil surface has been enlarged through etching chemically or electrochemically, and an oxide film is formed on the surface, through a chemical process of treating the aluminum foil with a chemical solution such as ammonium borate aqueous solution and the like. A cathode electrode foil 3 is also made of an etched aluminum foil of high purity. Capacitor element 1 is formed by the anode electrode foil 2 and the cathode electrode foil 3, wound together with intervening separator 11 made of manila paper and the like. Next, the capacitor element 1, after impregnating with electrolyte solution for driving the electrolytic capacitor, is housed into a bottomed outer case 10 made of aluminum and the like. The outer case 10 is equipped at the opening with a sealing member 9 made of an elastic rubber.

The anode electrode foil 2 and the cathode electrode foil 3 are each connected to lead wires 4 and 5, employed as electrode leads to lead the electrodes, by stitching, ultrasonic welding, and the like, as shown in FIG. 2. Each of the lead wires 4 and 5 is comprised of a rod member 6 made of aluminum, and a connecting member 7 that comes into contact with each of the electrode foils 2 and 3, and further an outside connecting

member 8 made of solderable metal which has been fixed at the tip of the rod member 6.

An electrolyte solution for driving the electrolytic capacitor having high conductivity, and to be impregnated to the capacitor element, γ-butyrolactone is employed as the main solvent, quaternized cyclic amidin compounds (imidazolinium cation and imidazolium cation) as the cationic component, and acid conjugated bases as the anionic component are dissolved therein as the solute (refer to Unexamined Published Japanese Patent Application No. H08-321449 and No. H08-321441) .

However, due to the remarkable development of digital information devices in recent years, the high-speed driving frequency of micro-processor which is a heart of these electronic information devices is in progress. Accompanied by the increase in the power consumption of electronic components in the peripheral circuits, the ripple current is increased abnormally, and there is a strong demand that the electrolytic capacitors used in these circuits have a low impedance characteristic.

Moreover, in the field of vehicles, with the recent tendency toward improved automobile functions, a low impedance characteristic is in high demand. Additionally, the prior driving voltage of the vehicle circuit of 14V, has been progressed to 42V accompanied by the increase in the power consumption. To comply with such a driving voltage, the electrolytic capacitor requires the withstand voltage characteristic of 28V and 84V and greater. Furthermore, the electrolytic capacitors must withstand high temperature in this field, and a high temperature life characteristic is in demand.

However, the electrolytic capacitor cannot cope with the low impedance characteristic as such. Moreover, although the withstand voltage of 28V is capable, the limit is 30V, and it cannot respond to the requirement of the high withstand voltage of

84V and greater. Moreover, these electrolytic capacitors suffer from a problem that the moisture resistant characteristic is low despite of the fact that the moisture resistance of these electrolytic capacitors are in demand similar to the semiconductors.

Henceforth, the present invention aims to provide an electrolytic capacitor having a low impedance characteristic and a high withstand voltage characteristic of a 100V class, an excellent high temperature life characteristic and an excellent moisture resistant characteristic.

SUMMARY OF THE INVENTION

A first electrolytic capacitor of the present invention comprises a capacitor element fabricated by winding an anode foil and a cathode foil via a separator impregnated with electrolyte solution, an outer case for housing the capacitor element, a sealing member for sealing an open part of the outer case, wherein the electrolyte solution contains an aluminum tetrafluoride salt, and wherein the separator is a heat resistant synthetic resin or a mixed paper containing glass fiber.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is an inner cross-sectional view showing an electrolytic capacitor structure; and

FIG. 2 is a decompositional oblique view showing an electrolytic capacitor structure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Aluminum electrolytic capacitors have a structure the same as the conventional structure, as shown in FIGS. 1 and 2. Capacitor element 1 is formed by an anode electrode foil 2 and a cathode electrode foil 3, wound together with intervening separator 11. Moreover, as shown in FIG. 2, lead wires 4 and 5, employed as the electrode leads, are connected to the anode electrode foil 2 and the cathode electrode foil 3, respectively. The lead wires 4 and 5 are comprised of connecting members 7 that come into contact with both electrode foils; rod members 6 connected to the connecting members 7; and an outer connecting member 8 welded to the rod member 6. Further, each foil and lead wire is mechanically connected by stitching, ultrasonic welding, and the like.

The anode electrode foil 2 used is obtained by subjecting an aluminum foil of a purity of 99% first to chemical or electrochemical etching in an acidic solution to enhance the surface area thereof and then second to a chemical treatment in an ammonium borate or ammonium adipate aqueous solution, so as to form an anode oxide film layer on the surface thereof.

The capacitor element 1 impregnated with electrolyte solution is housed in an aluminum cylindrical outer case 10 with a bottom, and a sealing member 9, having a perforation hole for guiding the lead wires 4 and 5, by insertion into an open end of the outer case 10, and further, the open end of the outer case 10 is sealed.

A separator of the present invention is made of heat-resistant synthetic resin. Examples of the separator include fabric, nonwoven fabric, paper, and porous film. In other words, the fabric, nonwoven fabric or paper is made by using the high-molecular fibers such as polyester, polyamide, vinylon, rayon, aramid, poly ethylene terephthalate,

polyethylene naphtahalate, poly phenylene sulfide, aromatic polyester, polyimide, polyamido-imido, polyetherimide, polytetrafluoroethylene, polyaminobismaleimide, poly(ethylene-tetraethylene), poly(vinylidene fluoride), and the like, or using the high porous film made by using these high molecules. Examples of resins used as binders include epoxy resin, phenol resin, polyurethene resin, and melamine resin. Due to the low tensile strength and low heat resistance nature of polypropylene, polyethylene and the like, winding the capacitor element is going to be difficult using these and thus not preferable.

The electrolyte solution of the electrolytic capacitor used in the present invention contains an aluminum tetrafluoride salt.

As an anion component, examples of this salt include an ammonium salt, an amine salt, a quaternary ammonium salt. A quaternary cyclic amidinium ion can be used as a cation component. Examples of an amine constituting the amine salt include a primary amine (such as methylamine, ethylamine, propylamine, butylamine, ethylenediamine, monoethanolamine, and the like); secondary amine (such as dimethylamine, diethylamine, dipropylamine, ethy-methylamine, diphenylamine, diethanolamine and the like); and tertiary amine (such as trimethylamine, triethylamine, tributylamine, triethanolamine, and the like). Examples of a quaternary ammonium constituting the quaternary ammonium salt include a tetraalkylammonium (such as tetramethylammonium, tetraethylammonium, tetrapropylammonium, tetrabutylammonium, methyltriethylammonium, di-methyldiethylammonium and the like) and a pyridinium (such as 1-methylpyridinium, 1-ethylpyridinium, 1,3-diethylpyridinium and the like).

Furthermore, as for salt containing the quaternized cyclic amidinium ion as a cationic component, the quaternized cyclic amidinium ion is a cation formed by quaternized a cyclic compound having an N,N,N'-substituted amidine group, and the following compounds are exemplified as the cyclic compound having an N,N,N'-substituted amidine group. They are an imidazole monocyclic compound (for example, an imidazole homologue, such as 1-methylimidazole, 1-phenylimidazole, 1,2-dimethyl-imidazole, 1-ethyl-2-methylimidazole, 2-ethyl-1-methylimidazole, 1,2-diethylimidazole, 1,2,4-trimethylimidazole and the like, an oxyalkyl derivative, such as 1-methyl-2-oxymethylimidazole, 1-methyl-2-oxyethyl-imidazole, and the like, a nitro derivative such as 1-methyl-4(5)-nitroimidazole, and the like, and an amino derivative such as 1,2-dimethyl-5(4)-aminoimidazole, and the like), a benzoimidazole compound (such as 1-methylbenzoimidazole, 1-methyl-2-benzylbenzoimidazole, 1-methyl-5(6)-nitrobenzo-imidazole and the like), a compound having a 2-imidazoline ring (such as 1-methylimidazoline, 1,2-dimethylimidazoline, 1,2,4-trimethylimidazoline, 1-methyl-2-phenylimidazoline, 1-ethyl-2-methylimidazoline, 1,4-dimethyl-2-ethyl-imidazoline, 1-methyl-2-ethoxymethylimidazoline, and the like), a compound having a tetrahydropyrimidine ring (such as 1-methyl-1,4,5,6-tetrahydropyrimidine, 1,2-dimethyl-1,4,5,6-tetrahydropyrimidine, 1,8-diazabicyclo[5,4,0]undecen-7,1,5-diazabicyclo[4,3,0]-nonene-5, and the like), and the like.

The solvent used for the electrolyte solution according to the present invention comprises a polar aprotic solvent, a polar aprotic solvent, and their mixture thereof. Examples of the polar aprotic solvent include monohydric alcohols (such as ethanol, propanol, butanol, pentanol, hexanol, cyclo-butanol, cyclo-pentanol, cyclo-hexanol,

benzyl alcohol, and the like); and polyhydric alcohol and oxy alcohol compounds (such as ethylene glycol, propylene glycol, glycerine, methyl cellosolve, ethyle cellosolve, methoxy propylene glycol, dimethoxy propanol, and the like). Moreover, representative examples of the aprotic polar solvent include amide series (such as N-methylformamide, N,N-dimethylformamide, N-ethylformamide, N,N-diethylformamide, N-methyl acetamide, N,N-dimethyl acetamide, N-ethyl acetamide, N,N-diethyl acetamide, hexamethylphosphoric amide, and the like); lactone compounds (such as .gamma.-butyrolactone, .delta.-valerolactone, .gamma.-valerolactone, and the like); sulfolane series (such as sulfolane, 3-methyl sulfolane, 2,4-dimethyl sulfolane, and the like); cyclic amide compounds (such as N-methyl-2-pyrrolidone, and the like); carbonates (such as ethylene carbonate, propylene carbonate, isobutylene carbonate, and the like); nitrite compound (such as acetonitrile, and the like); sulfoxide compound (such as dimethyl sulfoxide, and the like); 2-imidazolidinone solvents [for example, 1,3-dialkyl-2-imidazoridinone (such as 1,3-dimethyl-2-imidazoridinone, 1,3-diethyl-2-imidazoridinone, 1,3-di(n-propyl)-2-imidazoridinone, and the like); and 1,3,4-trialkyl-2-imidazoridinone (such as 1,3,4-trimethyl-2-imidazoridinone, and the like)], and the like. Among them, .gamma.-butyrolactone is preferably used because the impedance characteristic improves. Sulfolane, 3-methyl sulfolane, and 2,4-dimethyl sulfolane are preferably used because the high temperature characteristic improves. Ethylene glycol is preferably used because the withstand voltage characteristic improves.

Accordingly, the electrolyte solution containing aluminum tetrafluoride salt is used in the electrolytic capacitor of the present invention. The electrolytic capacitor of the present invention has a low impedance characteristic, and a high temperature withstand

voltage characteristic. Because the separator is made of heat resistant synthetic resin, moisture from the separator is less likely to be mixed into the electrolyte solution, so that the electrolytic capacitor has excellent high temperature life characteristic. That is to say, in the case of using a separator from the conventional manila paper and the like, the moisture is generated from the separator, and the reactivity of the electrolyte solution used in the present invention with the electrode foil is large to positively influence the life characteristic. However, in the present invention, moisture generation is controlled to obtain an excellent high temperature life characteristic. Furthermore, the moisture resistance characteristic is excellent.

Accordingly, a first electrolytic capacitor of the present invention described above has the low impedance characteristic and the high withstand voltage characteristic of 100V class, wherein the electrolytic capacitor provides the excellent high temperature life characteristic and the excellent moisture resistance characteristic.

Subsequently, a second electrolytic capacitor of the present invention will be explained. The electrolytic capacitor of the present invention comprises a capacitor element fabricated by winding an anode foil and a cathode foil via a separator impregnated with electrolyte solution, an outer case for housing the capacitor element, a sealing member for sealing an open part of the outer case, wherein the electrolyte solution contains an aluminum tetrafluoride salt, and wherein the separator is a mixed paper containing glass fiber.

The electrolytic capacitor has the same structure as the first electrolytic capacitor. As the separator, a mixed paper containing glass fiber is used. Examples of the mixed fibers include pulp fiber used in papers such as manila paper, craft paper and the like; and

the synthetic fibers such as polyester fiber, polyethylene fiber, polypropylene fiber, polytetrafluoroethylene fiber, polyamido fiber, and the like. When a separator made only from glass fiber is used, a thickness of the separator increases, and the impedance of electrolytic capacitor gets large. The effectiveness of the electrolytic capacitor of the present invention is not obtainable by using such a separator made only from fiberglass.

Accordingly, the electrolyte solution containing aluminum tetrafluoride salt is used in the electrolytic capacitor of the present invention. The electrolytic capacitor of the present invention has a low impedance characteristic and a high temperature withstand voltage characteristic. Because the separator is made of mixed paper containing glass fiber, the moisture from the separator is less likely to be mixed into the electrolyte solution, so that the electrolytic capacitor has excellent high temperature life characteristics. That is to say, in the case of using a separator made from the conventional manila paper and the like, the moisture is generated from the separator, and the reactivity of the electrolyte solution used in the present invention with the electrode foil is large to positively influence the life characteristic. However, such the present invention, the moisture generation is controlled to obtain an excellent high temperature life characteristic. Furthermore, the moisture resistance characteristic is excellent.

The second electrolytic capacitor of the present invention described above has the low impedance characteristic, the high withstand voltage characteristic of 100V class, and the excellent moisture resistance characteristic.

Further features of the first and second electrolytic capacitors of the present invention will be described below. The electrode foil subjected to phosphate treatment is used as the electrode foils. The present invention is still effective by using the electrode

foil subjected to phosphate treatment as one of the cathode electrode foil and the anode electrode foil. Deterioration of both foils is prevented if this is applied to both foils so normally both foils are subjected to phosphate treatment. Normally, an aluminum foil of high purity is subjected to chemical or electrochemical etching to obtain the etching foil; however, as the electrode foil of the present invention, the etching foil is obtained by performing the phosphate aqueous solution impregnation process before, during, or after etching process and is used as the cathode electrode foil. Further, for the anode electrode foil, the etching foil untreated with phosphate is subjected to phosphate synthesis, or the electrode foil subjected to the phosphate impregnation process before, during, or after the chemical treatment is used.

Furthermore, the effect of the present invention improves by adding the phosphorous compounds to the electrolyte solution of the electrolytic capacitor described above. Examples of phosphorus compounds and salts thereof include orthophosphoric acid, phosphorus acid, hypophosphorus acid and their salts. As the salts of the phosphorus compounds, an ammonium salt, an aluminum salt, a sodium salt, a calcium salt, and a potassium salt can be used. Moreover, examples of phosphorous compound include ethyl phosphate, diethyl phosphate, butyl phosphate, dibutyl phosphate and the like; and phosphonate such as 1-hydroxyethylidene-1,1-diphosphonic acid, aminotrimethylene phosphonic acid, phenyl phosphonic acid, and the like. Moreover, examples of phosphinate include methyl phosphinate, butyl phosphinate, and the like.

Furthermore, examples of condensed include straight-chain condensed phosphates such as pyrophosphoric acid, tripolyphosphoric acid, tetrapolyphosphoric acid, and the like; cyclic condensed phosphates such as metaphosphate, hexametaphosphate, and the

like, or the combination of the chain condensed phosphate and cyclic condensed phosphate. Further, as salts of these condensates, an ammonium salt, an aluminum salt, a sodium salt, a calcium salt, a potassium salt, and the like can be used.

The addition amount ranges from 0.05 to 3% by weight, and preferably ranges from 0.1 to 2% by weight.

The electrolytic capacitor of the present invention described above has the low impedance characteristic and the high withstand voltage of 100V class, and the excellent high temperature life characteristic. In other words, in the case of performing the high temperature life test by using the aluminum tetrafluoride salt, the reactivity of the electrolyte solution with the electrode foil is large due to the moisture inside the electrolyte solution, and the characteristics are positively affected. However, since the electrolytic capacitor of the present invention utilizes the electrode foil subjected to phosphate treatment, the reaction of the electrode foil with the electrolyte solution is controlled, whereby the high temperature life characteristic is stabilized.

Furthermore, similarly, in the present invention, a partial crosslinking peroxide butyl rubber with added peroxide as cross-linking agent to a butyl rubber polymer comprised of isobutylene, isoprene, and divinylbenzene copolymer is used as the sealing member. Examples of vulcanizing agents used in the vulcanization of peroxides include ketone peroxides, peroxy ketals, hydro-peroxides, dialkyl peroxides, diacyl peroxides, peroxy dicarbonates, peroxy esters, and the like. Specific examples are 1,1-bis-t-butylperoxy-3,3,5-trimethylcyclohexane, n-butyl-4,4-bis-t-butylperoxy-valerate, dicumyl peroxide, t-butyl-peroxy-benzoate, di-t-butyl-peroxide, benzoyl peroxide, 1,3-bis (t-butyl peroxy-isopropyl)benzene, 2,5-dimethyl-2,5-di-t-butylperoxyl-hexene-3, t-butyl peroxy

cumene, .alpha., .alpha.' bis(t-butylperoxy) diisopropylbenzene, and the like.

According to the electrolytic capacitor of the present invention, a partial cross-linking peroxide butyl rubber with added peroxide as cross-linking agent to a butyl rubber polymer comprised of isobutylene, isoprene, and divinylbenzene copolymer is used as the sealing member. The electrolyte solution containing the aluminum tetrafluoride salt is used. The electrolytic capacitor of the present invention has a low impedance characteristic, and a high withstand voltage characteristic of 100V class. The high temperature life characteristic is improved further by the excellent high temperature characteristics of the electrolyte solution and the sealing member of the present invention.

Moreover, the quaternary cyclic amidinium compound tends to cause leakage due to the reaction with the hydroxyl ion generated in the vicinity of the cathode leading means; however, the electrolyte solution used in the present invention seemingly has less reactivity with the hydroxyl ion, and owing to the excellent sealability between the perforation hole of the sealing member and the lead wire, the leakage characteristic is further improved by these synergistic effects.

With reference to the below tables, illustrative embodiments of the invention use a separator composed of poly ethylene terephthalate (PET). A convention separator made of manila paper is used in the comparative examples.

The electrolyte solution A contained 75% by weight of .gamma.-butyrolactone as solvent and 25% by weight of 1-ethyl-2,3-dimethylimidazolinium aluminum tetrafluoride salt as solute. The electrolyte B solution contained 80% by weight of .gamma.-butyrolactone as solvent and 20% by weight of 1-ethyl-2,3-dimethylimidazolinium aluminum tetrafluoride salt as solute. Further, the electrolyte solution C contained 75%

by weight of gamma-butyrolactone as solvent and 1-ethyl-2,3-dimethylimidazolinium hydrogen phthalate salt as solute is used as the electrolyte solution containing conventionally used electrolyte.

The rated voltages of the electrolytic capacitors using the electrolyte solutions A and C are 16V, and that of using the electrolyte solution B is 100V. The characteristics of the electrolytic capacitors are evaluated. The test condition is 125.degree. C. at 2,000 hours in the loaded state, and 105.degree. C. at 2,000 hours in the unloaded state. The results are shown in (Table 1-1) to (Table 1-4).

(Table 1-1)

	Electrolyte	Separator	Initial Characteristic		125ºC/1000 hrs loaded	
			Cap (μF)	Tan δ	Δ cap (%)	Tan δ
Embody 1	A	PET	401	0.022	-7.6	0.030
Compare 1	A	Manila Paper	401	0.027	-7.9	0.036
Compare 2	C	Manila Paper	406	0.046	-5.8	0.060

(Table 1-2)

	Electrolyte	Separator	Initial Characteristic		105ºC/1000 hrs unloaded	
			Cap (μF)	Tan δ	Δ cap (%)	Tan δ
Embody 1	A	PET	403	0.022	-2.8	0.022
Compare 1	A	Manila Paper	400	0.028	-3.0	0.028
Compare 2	C	Manila Paper	406	0.046	-4.1	0.046

(Table 1-3)

	Electrolyte	Separator	Initial Characteristic		125ºC/1000 hrs loaded	
			Cap (μF)	Tan δ	Δ Cap (%)	Tan δ
Embody 2	B	PET	22.7	0.010	-2.1	0.015
Compare 3	B	Manila Paper	22.9	0.011	-2.3	0.018

(Table 1-4)

	Electrolyte	Separator	Initial Characteristic		125ºC/1000 hrs unloaded	
			Cap (μF)	Tan δ	Δ cap (%)	Tan δ
Embody 2	B	PET	22.8	0.010	-1.6	0.010
Embody 3	B	Manila Paper	22.9	0.011	-2.0	0.012

As (Table 1-1) and (Table 1-2) clearly show, the electrolytic capacitor of the first embodiment has the excellent high temperature life characteristics, a low dielectric loss coefficient (tan .delta.), and a lower change in the dielectric loss coefficient (tan .delta.) at 125.degree. C., compared with the electrolytic capacitor of the comparative examples 1 and 2. Furthermore, (Table 1-3) and (Table 1-4) clearly show the excellent life characteristics and initial characteristics of the rated voltage 100V, to implement the 100V class electrolytic capacitor having a low impedance characteristic not found in the conventional ones.

Subsequently, the moisture resistance characteristics of the electrolytic capacitors of the first embodiment and the first comparative example are evaluated. The test conditions are 85.degree. C., 85% RH, at 1,000 hours in the unloaded state. The results are shown in (Table 1-5).

(Table 1-5)

	Electrolyte	Separator	Initial Characteristic		85°C/85%RH/ 1000 hrs unloaded	
			Cap (μF)	Tan δ	Δ cap (%)	Tan δ
Embody 1	A	PET	402	0.022	-2.0	0.024
Compare 1	A	Manila Paper	401	0.028	-2.3	0.030

As (Table 1-5) clearly shows, the electrolytic capacitor of the present invention has excellent characteristics in the change in electrostatic capacity and the dielectric loss coefficient. The moisture resistance characteristic of the electrolytic capacitor of the present invention has improved.

Subsequently, the second electrolytic capacitor of the present invention will be described. This electrolytic capacitor has the same structure as that of the first electrolytic capacitor, and the contents of characteristic evaluation which are also the same. The

separator was composed of mixed paper containing glass fiber. A conventional separator made of manila paper was used in the comparative examples. The results are shown in (Table 2-1) and (Table 2-4).

(Table 2-1)

	Electrolyte	Separator	Initial Characteristic		125ºC/1000 hrs loaded	
			Cap (μF)	Tan δ	Δcap (%)	Tan δ
Embody 3	A	Glass fiber	403	0.022	-7.5	0.030
Compare 4	A	Manila Paper	400	0.027	-7.8	0.036
Compare 5	C	Manila Paper	405	0.046	-5.7	0.060

(Table 2-2)

	Electrolyte	Separator	Initial Characteristic		105ºC/1000 hrs unloaded	
			Cap (μF)	Tan δ	Δcap (%)	Tan δ
Embody 3	A	Glass fiber	404	0.022	-2.9	0.022
Compare 4	A	Manila Paper	401	0.028	-3.2	0.028
Compare 5	C	Manila Paper	405	0.046	-4.1	0.046

(Table 2-3)

	Electrolyte	Separator	Initial Characteristic		125ºC/1000 hrs loaded	
			Cap (μF)	Tan δ	Δcap (%)	Tan δ
Embody 4	B	Glass fiber	22.7	0.011	-2.2	0.015
Compare 6	B	Manila Paper	22.8	0.011	-2.5	0.018

(Table 2-4)

	Electrolyte	Separator	Initial Characteristic		105ºC/1000 hrs unloaded	
			Cap (μF)	Tan δ	Δcap (%)	Tan δ
Embody 4	B	Glass fiber	22.7	0.010	-1.7	0.010
Compare 6	B	Manila Paper	22.9	0.011	-2.2	0.012

As (Table 2-1) and (Table 2-2) clearly show, the electrolytic capacitor of this embodiment has excellent high temperature life characteristics, a lower change in dielectric loss coefficient (tan .delta.) of 125.degree. C., and a low dielectric loss coefficient (tan .delta.), compared with the electrolytic capacitor of the comparative example. Furthermore, (Table 2-3) and (Table 2-4) clearly show the excellent life characteristics and initial characteristics of the rated voltage 100V, to implement the 100V class electrolytic capacitor having the low impedance characteristic not found in the conventional ones.

Subsequently, the moisture resistance characteristics of the electrolytic capacitors of the third embodiment and the fourth comparative example are evaluated. The test conditions are 85.degree. C., 85% RH, at 4,000 hours in the unloaded state. The results are shown in (Table 2-5).

(Table 2-5)

	Electrol yte	Separator	Initial Characteristic		85°C/85%RH/ 1,000 hrs	
			Cap (μF)	Tan δ	Δ cap (%)	Tan δ
Embody 3	A	Glass fiber	403	0.022	-2.1	0.024
Embody 4	A	Manila Paper	402	0.028	-2.4	0.030

As (Table 2-5) clearly shows, the electrolytic capacitor of the present invention have the excellent characteristics in the change in electrostatic capacity and the dielectric loss coefficient. The moisture resistance characteristic of the electrolytic capacitor of the present invention has improved.

As for first second third electrolytic capacitors, in case of using an electrode foil subjected to phosphate treatment as the anode electrode foil and the cathode electrode foil, the high temperature life characteristic improved further. The high temperature life

characteristic also improves by adding phosphorous compound to the electrolyte solution. Moreover, in case of using, as the sealing member, a partial cross-linking peroxide butyl rubber with added peroxide as cross-linking agent to a butyl rubber polymer comprised of isobutylene, isoprene, and divinylbenzene copolymer. Namely, the present invention achieves an extremely remarkable effect of preventing liquid leakage.

According to the present invention, an electrolyte solution containing an aluminum tetrafluoride salt is used, and a separator composed of heat resistant synthetic resin or a mixed paper containing glass fiber is used. Thus, the electrolytic capacitor has the low impedance characteristic, the high voltage characteristic, the excellent high temperature life characteristic and the moisture resistance characteristic.